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Agricultural Memorandum No. 961

An Evaluation of MORECS - Implications for Future Development

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Introduction

The MAFF experimental horticultural station (EHS) at Luddington is currently in receipt of the results from three different schemes which calculate a moisture balance for their site. This memorandum analyses and compares the results from two of these, the ARC/NVRS system (scheme A) and MORECS (scheme B) and gives brief details on the third, mainly that supplied by Fisons (now called Norsk Hydro Fertilisers) at Levington (scheme C).

The comparison covers the period from 7 April to 21 September and some of the advantages and disadvantages of the different schemes, as well as possible improvements, are discussed.

The Schemes

A. ARC/NVRS scheme.

The Agricultural Research Council station at East Malling developed a FORTRAN computer program some years ago to calculate potential evaporation (PE) and potential soil moisture deficit (PSMD) given daily site values of maximum and minimum temperature, vapour pressure, wind speed, sunshine and rainfall.

This program is now run operationally once weekly by the NVRS of Wellesbourne throughout the summer months to calculate PE and PSMD for Luddington using the locally measured meteorological data. The results are made available at Luddington some four to five days in arrears.

The algorithm used to calculate PE is based on that developed by Penman (1948) and the value is used in conjunction with the daily rainfall to produce a daily value for PSMD. No attempt is made to calculate actual evaporation (AE) in order to derive an approximation to the actual SMD. The calculations are performed for a grass covered surface. Annex A illustrates the computer output

B. The Meteorological Office Rainfall and Evaporation Calculation System (MORECS) has been used operationally for more than five years. During this time various improvements have been made and the system has been extensively revised

model (Thompson et al, 1981) which was brought into operational use in May 1981. The current system has now been tested over two summers and, apart from some minor improvements in March 1982, has remained unchanged. No further changes in the method of calculation are anticipated as the results so far produced are considered to be within the limits of accuracy imposed by the input data.

The values calculated are area averaged values covering the whole of the U.K (except Northern Ireland) and include PE, AE, SMD and excess rainfall (HER) for three soils of different available water capacity (AWC) and twelve crop types, but only the grassland ones are used here. Week ending and weekly total, or mean, data are produced with the daily values stored but not routinely available. Each calculated value is for a 40 x 40 km square with the input met. data being derived from nearby stations to produce an estimate for each element. Annex B contains a specimen of the type of information available. A graphical representation of the data is also produced.

C. Fisons.

No detailed description of their scheme could be found, but on a weekly basis the Met. Office at Bracknell supplies, by telex, daily values of PE for open water for over forty met. stations in Eastern and Southern England. Fisons supplement this telex with data collected from other met. stations in the area, to compile a field of daily PE values.

Each week the people in receipt of this irrigation advice inform Fisons of the daily recordings of rainfall for their own site. Fisons then run their computer program to balance the rainfall against the evaporation estimates, taking modified values of PE depending on the crop in question and the soil type on which it is growing.

A summary sheet is issued to the customer (see Annex C) containing information on rainfall, evaporation, drainage and a guide to the amount of irrigation needed by the crop. The values supplied to Luddington during 1982 related to onion and blackcurrant plots.

General comments

Perhaps the single most significant difference between the three schemes is in the method of using rainfall data. Schemes A and C use daily rainfall for specific sites, whereas scheme B uses area averaged values. As PE is a fairly conservative property over an area, whereas rainfall can be extremely variable, schemes A and C have an obvious advantage for an accurate calculation of SMD (or PSMD) for any

particular site where rainfall measurements are made. However, the daily value for rainfall as calculated by MORECS should be a more accurate value over a large area, but for single site values it tends to smooth out any perhaps unrepresentative large falls reported, and increases some of the lesser ones. Over the course of several months this tends to be self-compensating and is helped by the lower values of the AE when a heavy fall is missed, but for a particular day or week the difference can be large.

A significant improvement in the representative nature of the daily grid square rainfall is possible if the output from rainfall measuring weather radars can be combined operationally with the existing synoptic rainfall stations network. There are plans to utilise the radar data in this way.

Input data compared.

MORECS does not use any of Luddington's data for input so it is informative to compare the met. data derived by MORECS for the relevant square (square 136) with the actual measurements made at Luddington.

Small corrections were made to the MORECS values to account for the difference in altitude between Luddington at 56m and the mean altitude of grid square 136, at 85m. The MORECS daily mean temperatures were increased by 0.2°C . In addition the wind speed was multiplied by a factor of 0.78 to reflect the likely decrease in wind speeds between the standard height of 10m, as used in MORECS, and the height of 2m, at which the Luddington cup-counter anemometer is exposed.

Table 1 lists the differences between the two sets of input data (and usually the squared difference) for the twenty four weeks covering the period 7 April to 21 September 1982. For the sake of completeness the computed values for PE and (P)SMD are included.

Table 1

COMPARISON OF INPUT AND OUTPUT VALUES FOR MORECS (SUFFIX M) AND LUDDINGTON (SUFFIX L)

Week ending	INPUT					OUTPUT	
	MEAN TEMP °C	RAINFALL mm	SUNSHINE hrs	WIND miles/day	VAPOUR PRESSURE m	POTENTIAL EVAPORATION mm	SOIL MOISTURE DEFICIT mm
	$(T_M - T_L)^2$	$\Sigma(R_M - R_L)$	$(S_M - S_L)^2$	$(W_M - W_L)^2$	$(VP_M - VP_L)^2$	$(PE_M - PE_L)^2$	$(SMD_M - PSMD_L)^2$
13/4	1.22	4.0	36	1156	0.49	6.25	1
20/4	0.01	4.0	1	256	0.36	1.0	4
27/4	0.04	4.0	9	289	1.21	1.0	4
4/5	1.00	-4.5	0	3600	0.36	16.0	196
11/5	0.01	-9.0	25	36	1.96	4.0	400
18/5	0.25	-5.7	4	81	1.69	25.0	256
25/5	1.00	-6.3	1	484	0.16	1.0	169
1/6	0.64	-5.1	36	25	1.44	1.0	25
8/6	0.09	-22.0	49	1	2.25	0.0	441
15/6	0.04	-18.7	1	49	0.25	1.0	256
22/6	0.36	-14.8	1	9	0.25	1.0	144
29/6	0.04	-7.0	81	16	0.81	2.25	25
6/7	0.25	-4.8	9	1	0.81	0.0	9
13/7	0.04	-1.2	49	324	0.09	4.0	9
20/7	0.00	-9.4	9	4	0.64	1.0	36
27/7	0.01	-9.4	16	144	0.04	0.25	25
3/8	1.21	-27.0	4	16	0.16	1.0	196
10/8	0.64	-19.2	25	256	0.00	1.0	36
17/8	0.01	-41.8	1	625	0.64	4.0	841
24/8	0.09	-37.6	0	361	0.04	0.0	576
31/8	0.00	-35.2	1	25	0.00	0.25	400
7/9	0.09	-34.4	4	289	0.49	4.0	225
14/9	0.01	-34.3	0	324	0.01	1.0	81
21/9	0.04	-27.7	4	4	0.09	16.0	0
TOTALS	7.08	-27.7	366	8375	13.84	91.8	4355

RMS Difference	0.54	-	3.91	18.7	0.76	1.96	13.5
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Table 2 MEAN VALUES OVER 24 WEEK PERIOD

Mean Values	Temp	Sun	Wind	VP	PE
MORECS	13.8	39.6	153	12.0	18.1
LUDDTN.	14.0	39.3	148	12.7	16.9

It is appropriate to note here the sequence of erroneous minimum temperature recordings made at Luddington. The values logged and used by Luddington during the period 25 May to 11 June were all too high, considerably so on occasion, and were subsequently queried following quality control procedures by the Met. Office. This will have had the effect of raising the daily mean temperature and increasing the calculated value of PE. The overall error will be small and no attempt is made to correct it in this memorandum. The values for daily mean temperatures during this period were estimated from values at nearby sites.

The results presented in tables 1 and 2 have a few points worth commenting on. The method of calculation by MORECS for daily mean values of temperature, vapour pressure and windspeed involve averaging the hourly values at 0300, 0900, 1500 and 2100 (or as available) with a back up procedure for temperature of "half of max-plus-min". The values for Luddington take the 0900 GMT V.P, the mean daily run of wind and for temperature, half of max plus min.

The comparatively large differences in the values for weekly mean vapour pressure can probably be accounted for by the different methods of calculation. An examination of ten years of hourly mean Boscombe Down values is summarised in table 3.

Table 3 Average values of vapour pressure (mb) - Boscombe Down (1971-80)

	Apr	May	June	July	Aug	Sept
a.	8.2	10.0	12.2	14.0	14.4	12.9
b.	7.9	9.7	11.9	13.7	13.9	12.5
c.	7.8	9.7	11.9	13.7	13.8	12.4

where a is the 0900 average value for the month

b is the mean of the 03, 09, 15 and 2100 GMT values

and C is the true 24 hours daily mean.

As can be readily seen, using the 0900 GMT value as an estimate for the daily mean will tend to overestimate the true mean by 2 to 5%. The averaging method used by MORECS gives a value somewhat closer to the true daily mean.

The mean weekly temperature and sunshine values are in very close agreement with each other, as are the 2m wind speeds.

The monthly total rainfall values for Luddington, MORECS and five other rainfall recording sites scattered throughout grid square 136 are given in table 4. This shows that Luddington recorded one of the highest period (April - September) totals in this square, and in this instance anyway, the MORECS value falls comfortably in the middle of the range of recordings.

Table 4

1982 MONTHLY RAINFALL TOTALS (MM) FROM SITES IN GRID SQUARE 136

Site Altitude(m) NGR Month	Luddington 56 4167 2528	Hampton Park 30 4030 2446	Huddington Court 38 3941 2572	Oldington 44 3822 2739	Lye Bridge 104 4032 2717	Studley, Wickham 62 4075 2637	MORECS 85 mid-point 4000 2600
Apr	18	20	18	19	19	19	25
May	35	24	28	21	24	21	26
Jun	122	109	90	92	112	98	120
Jul	35	49	47	65	49	47	32
Aug	89	100	64	73	83	65	65
Sep	59	57	52	57	60	53	61
TOTAL	358	359	299	327	347	303	329

Evaporation Calculations

Given that, for most weeks, the data to be used in the calculation of evaporation by the two different schemes are in close agreement, any large differences in PE must be a function of the combination equation employed, or the other "constants" assumed in the different models.

The largest differences in the calculation of PE (see Table 1) are apparent during May, and perhaps again in late September, with the MORECS values (PE_M) being higher at both times. For the other weeks there is very good agreement between system A (ARC/NVRS) and system B (MORECS).

The higher values during May according to MORECS reflect the nature of potential grassland production which reaches a peak at this time. The abundance of fresh, young grass is reflected in the high PE values (see Hyd. Mem. 45 page 25, for monthly surface resistance and leaf area index (LAI) values).

By the same token the effect of taking these monthly values rather than daily interpolations will introduce some "stepping" in the calculations at the start of each month. The autumn values are not too apparent until October, with the

latter part of September still reflecting the late summer period. The surface resistance and LAI values are carefully fixed so the effect will not mask the more significant weather related factors which influence the evaporation calculations.

Sources of Error

The largest single source of disparity between the systems is in the value used for daily rainfall. The MORECS system is designed to give an areal rather than point estimate, and as such the values produced may differ quite markedly from a point value within a given square. The problems are compounded in the Luddington area as there are comparatively very few sites which can report their daily rainfall amounts directly to Bracknell, with Elmdon and RAF Brize Norton being the closest.

This paucity of rainfall values which are available to be used for input data into the interpolations routines, to convert point values into grid square estimates, is the source of much of the discrepancies between the schemes. The interpolation procedures do however produce objective estimates and in the case of rainfall the daily value is expressed as a percentage of annual rainfall, which is known for both met. station and grid square. The interpolations are done on the percentage to give regard to the influences of larger scale topographical features (see Hyd. Mem. 45 for more detail). Estimates are thus derived for grid squares containing no met. stations.

An illustration of possible implications of the system is given in figure 1. On the 2 June 1982 a large fall of rain was recorded at Chipping Campden just outside the SE corner of grid square 136. The highest weekly total was 103.4 mm with Luddington recording some 39.1 mm and compared to a more general value of around 10-20 mm for the remainder of the square. That week MORECS calculated a rainfall total of 22.2 mm; not unrealistic for the square as a whole but not a good reflection of the conditions at Luddington let alone the area to the SE corner.

Hence the problem: to attempt to give areal or point values, via an operational scheme for the U.K.

Possible Modifications to the MORECS Service

The operational MORECS model tries to satisfy a wide spectrum of customers. On one side there are the water authorities and chemical supply companies which have an interest over a large area, while on the other there is the farmer or grower who requires a value for perhaps only one field.

Obviously to satisfy such diverse requirements under one system is not easy, but the current MORECS options available do go some way towards this in presenting either the detailed tables for one grid square as shown in Annex B, or single parameter maps (ie for excess rainfall) for the whole country.

More could be done, and listed below are five possible courses which could be pursued to enhance or modify the current operational scheme.

1. base all calculations on recording sites, not squares.
2. incorporate more rainfall data (ie from water authorities)
3. include point estimate as well as grid square values
4. Increase the reporting network by using other recording sites
5. incorporate radar rainfall estimates on a grid square basis.

All of these suggestions have problems either in implementation or presentation of the data.

1. Single site calculations would give a greater accuracy for the place concerned, much as the old "Estimates Soil Moisture Deficit Bulletin" achieved during the last twenty years, but applications to larger catchment areas or county values could be extremely hazardous. An interpolation scheme could be employed, as with the other values, and contour maps could be issued to subscribers.
2. This has been tried in the past and the additional manpower involved proved the scheme unworkable. Technical problems prevented the automatic handling of the data.
3. This could be very attractive as it would incorporate both the large interests as at present, and additionally the person keeping a simple daily rainfall record for a trial site, irrigation plot etc. He would then have available quick and accurate estimates of soil moisture for his own particular interest. The difficulty with this is again the manual effort necessary to input the data and maintain the systemⁱⁿ the short space of time between receipt of the data (around 1030 GMT) and the running of the program (around 1200 GMT) each Wednesday.
4. There are many agricultural units and Ministry of Defence establishments around the country which currently do not keep met. records or do not report their recordings on a daily basis to the Met. Office. These places could be fully integrated into the synoptic network with a single report at 0900 GMT each day and thus help to fill some of the worst gaps in the present coverage. This would help to give a general improvement in the calculation of rainfall and SMD especially.

5. Possibly the most likely source of more accurate rainfall data. The existing radar rainfall network could give fairly accurate estimates of rainfall for much of the U.K in the near "real-time" and in a form which would require the minimum of human intervention. The outcome of a calibration scheme now under test will be crucial to the implementation, or not, of radar rainfall derived data.

Implications for Luddington and other subscribers

It has been shown that a good deal of faith can be placed in the accuracy of calculation of both the NVRS (scheme A) and MORECS (scheme B) systems. Apart from rainfall, the fact that MORECS can estimate the met values for a particular place from data from other sites is not a drawback. PE values from schemes A and B are in good agreement with each other.

All the above suggestions for improving the system, excepting No. 1, would raise the level of accuracy of rainfall data, which in turn would improve the accuracy of AE and SMD estimates, but only No. 3 would put MORECS on a similar footing to the NVRS and Fisons schemes with their advantages for single site estimates.

Any scheme introduced which requires extra manpower to maintain it would have to be reflected in either, a higher charge, or a much wider range of subscribers to keep the system financially viable.

It is regretted that an independent measurement of the soil moisture deficit using a neutron probe was not made during the period of the comparison.

Any comments or suggestions on this memorandum should be referred to the author.

Met.Unit
Wolverhampton
October 1982

References

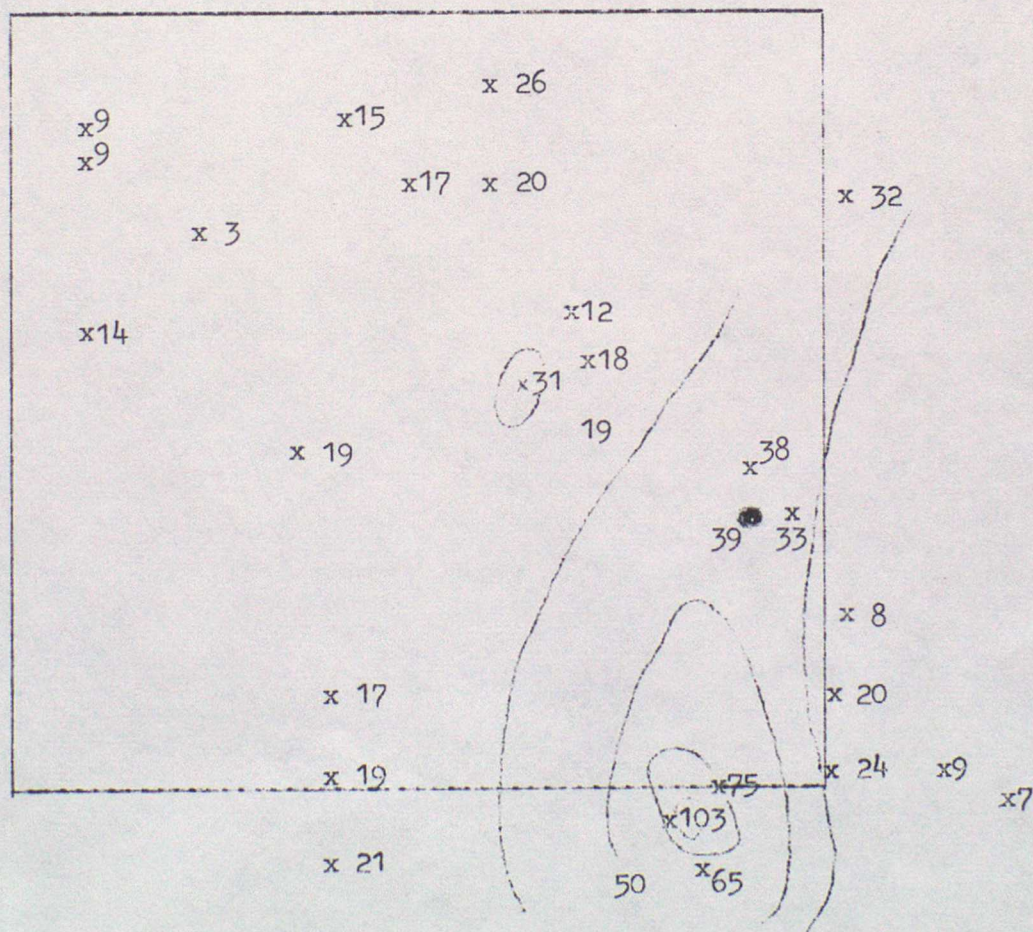
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Acknowledgement

Thanks are offered to G. Wood of Luddington EHS for making the data available,
and his useful comments.

FIGURE 1

Total rainfall amounts for week ending 8.6.82 - MORECS square 136
 • Luddington.



ANNEXE A

INPUT - DAILY VALUES (TEMP-DEG C; RAIN-MM)

D	M	Y	V.P.	MAX	MIN	RAIN	SUN	WIND
5	7	82	12.4	20.2	13.1	0.00	2.2	341.
6	7	82	16.8	22.6	13.8	0.00	4.1	252.
7	7	82	14.8	23.5	12.8	0.00	10.1	186.
8	7	82	19.2	27.4	15.2	0.00	10.6	234.
9	7	82	19.6	25.4	12.8	1.50	6.5	380.
10	7	82	14.1	23.2	11.7	0.00	6.6	200.
11	7	82	18.6	26.2	14.0	0.00	6.2	492.

CALCULATION OF DEFICIT (MM.)

D	M	Y	EVAP	DEC	EVAP	DEF
DATE			DAILY	ACCUMULATED		
5	7	82	3.034	3.034	227.561	65.549
6	7	82	2.598	2.598	230.159	68.147
7	7	82	3.500	3.500	233.660	71.648
8	7	82	3.986	3.986	237.645	75.633
9	7	82	2.941	1.441	240.586	77.074
10	7	82	2.988	2.988	243.574	80.062
11	7	82	3.679	3.679	247.253	83.741

ANNEX B

MORECS DATA FOR SQUARE 125 WEEK ENDING 6 7 82

TOTAL RAIN 3.2	TOTAL SUN 21	MEAN TEMP 14.6	MEAN WIND 199	MEAN V.P. 12.1
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CROP	SMD	HIGH AWC			HER	SMD	MEDIUM AWC			HER
		PE	AE				PE	AE		
BARE SOIL	16	16	15		0	14	15	14		0
GRASSLAND	50	17	17		0	45	17	17		0
SPRING BARLEY	59	21	21		0	52	21	21		0
WINTER WHEAT	68	21	21		0	61	21	21		0
WINTER BARLEY	68	15	15		0	60	15	15		0
EARLY POTATOES	26	16	15		0	17	15	14		0
M/C POTATOES	23	21	21		0	23	21	21		0
SUGAR BEET	21	20	20		0	21	20	20		0
DECID. TREES	64	20	20		0	57	20	20		0
ORCHARDS	57	19	19		0	51	19	19		0
CONIFEROUS	40	17	17		0	38	17	17		0
UPLAND	14	15	15		0	14	15	15		0
SPARE SPARE	***	**	**	***		***	**	**	***	
SPARE SPARE	***	**	**	***		***	**	**	***	
REAL LAND USE	41	16	15		0	37	16	15		0

CROP	SMD	LOW AWC			HER	KEY
		PE	AE			
BARE SOIL	12	14	12		0	PE- POTENTIAL
GRASSLAND	37	17	17		0	EVAPOTRANSPIRATION
SPRING BARLEY	43	21	21		0	AE- ACTUAL
WINTER WHEAT	50	21	21		0	EVAPOTRANSPIRATION
WINTER BARLEY	48	15	15		0	SMD-SOIL MOISTURE DEFICIT
EARLY POTATOES	12	14	12		0	AT 0900 HRS WEDNESDAY
M/C POTATOES	23	21	21		0	WEEK ENDING AS ABOVE
SUGAR BEET	21	20	20		0	HER-HYDROLOGICALLY
DECID. TREES	46	20	20		0	EFFECTIVE RAINFALL
ORCHARDS	42	19	19		0	AWC-AVAILABLE WATER
CONIFEROUS	32	17	17		0	CAPACITY
UPLAND	14	15	15		0	RAIN- (MM)
SPARE SPARE	***	**	**	***		WIND- MILES PER DAY
SPARE SPARE	***	**	**	***		SUN- HOURS
REAL LAND USE	30	16	15		0	V.P.- MILLIBARS

PRINCIPAL MET.OFFICER
MAFF ADAS
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WEST MIDS WV6 8TQ

0789 750 601

LUDDINGTON EHS
LUDDINGTON,
STRATFORD ON AVON,
WARMS,
CV37 9SJ

** FISON'S FERTILIZERS IRRIGATION ADVISORY SERVICE **

DATE: 16-AUG-82

SITE NO: 4518T

PERIOD START: 9-AUG-82

CROP: ONIONS

CROP COVER: 25 %

DEFICIT ON 9 AUG(MM)	PERIOD GAINS(MM)		POTENTIAL PERIOD LOSSES(MM)		DEFICIT ON 16 AUG(MM)
	RAIN	IRRIGATION	EVAPOTRANSF	DRAINAGE	
10.1	50.2	0.0	17.3	24.0	2.0

THE SOIL WATER DEFICIT COMPUTED FOR 16 AUG 82 SUGGESTS THAT
IRRIGATION IS UNLIKELY TO BE NEEDED BEFORE 23 AUG